Initial VLBI Data Analyses at the National Geographic Institute of Spain

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Abstract The National Geographic Institute of Spain (IGE) has been taking part in geodetic VLBI since 2008 through the participation of the Yebes 40-meter radio telescope in VLBI observation campaigns. It also encourages the continuous development of the RAEGE project for an Atlantic Network of Geodynamical and Space Stations, as part of the VLBI Geodetic Observing System. Currently, IGE is expanding its contribution to geodetic VLBI by taking its first steps in VLBI data analysis. We present in this work the results of the initial analyses carried out using VieVS 3.0 (University of Vienna) and Where (Norwegian Mapping Authority) as processing software. One-year series of Earth Orientation Parameters obtained from R1 and R4 IVS sessions are compared with IERS 14 C04 series and those from other VLBI Analysis Centers. In addition, secondary VLBI products such as zenith troposphere delay and clock offsets are also compared with GNSS-based products for stations in which VLBI and GNSS antennas' co-location make this analysis possible.

Keywords VLBI, VieVS, Where, EOP, GNSS

1 Introduction

The National Geographic Institute of Spain (IGE) has been taking part in geodetic VLBI over the last decades through the participation of the Astronomical Center of Yebes in VLBI observation campaigns. Regarding instrumentation, IGE encourages the development of the RAEGE project for an Atlantic Network of Geodynamical and Space Stations, as part of the VLBI Geodetic Observing System. As part of this project, VLBI antennas at Yebes (Spain) and Santa María (Azores) were installed. Currently, IGE is expanding its contribution to geodetic VLBI by taking its first steps in VLBI data analysis, whose results are shown in this work.

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2. RAEGE Santa Maria - National Geographic Institute of Spain
3. Astronomical Center of Yebes - National Geographic Institute of Spain

2 Goal

The aim of this work is to present the first VLBI data analysis results obtained at IGE. Several topics have been addressed during this work:

- Processing VLBI sessions for the same period of time by using different VLBI processing software; namely VieVS 3.0 (Boehm et al., 2018) and Where (Kirkvik et al., 2017).
- Comparing and contrasting the Earth Orientation Parameters (EOP) estimated by means of these programs and the solutions of other Analysis Centers with the IERS EOP 14 C04 series (Bizouard et al., 2018), which are used as a reference.
- Comparing the time series of the estimated station coordinates with the IVS combined solution (Schuh and Behrend, 2012).
- Validating the workflow and products obtained by comparing the VLBI troposphere estimation with the final IGS tropospheric Zenith Total Delay (ZTD) calculated with GNSS (Dow et al., 2009).

3 Strategy

IVS R1 and R4 sessions for the period spanning from October 2016 to October 2017 were used for the experimentation activities with the VLBI processing programs previously mentioned. The a priori models and configuration used in each software is reflected here, below.

1. IGE VieVS
   - Frames: ICRF2 and VTRF14
   - EOP: IERS Conventions 2010 and Bulletin A as initial value
   - Troposphere: VMF1 model
   - Geophysical models: solid tide, tidal ocean loading (FES2004), tidal atmosphere loading (Vienna model), thermal antenna deformation
   - Estimation model: weighted least squares
2. IGE Where
   - Frames: ICRF2 and VTRF14
   - EOP: IERS Conventions 2010 and Bulletin B as initial value
   - Troposphere: VMF1 model
   - Geophysical models: solid tide, tidal ocean loading (TPXO.7.2), thermal antenna deformation
   - Estimation model: Kalman filter

In both cases, the estimated parameters are EOP, station and source coordinates, station clock models, troposphere delay, and gradients.

4 Results

- EOP analysis

EOP estimations for the one-year period analyzed with VieVS 3.0 and Where software have been compared to IERS EOP 14 C04 using spline interpolation. The same comparison has been carried out using EOP estimated by other Analysis Centers such as BKG (Calc/Solve) and GFZ (VieVS) as well as with the IVS combined solution. These solutions were retrieved from IVS ftp. Figures 1 to 5 show the differences of each AC with respect to the IERS EOP 14 C04 series, and Table 1 includes a statistical summary of the differences.

- Time series of station coordinates

Station and source coordinates are part of the estimation process when dealing with VLBI observations. In order to validate other outputs obtained during the reprocessing campaign carried out by IGE, one-year time series of Wettzell station coordinates estimated with VieVS were compared with the IVS combined solution, which is available at IVS ftp through SINEX files. The same comparison has been performed using BKG and GFZ time series. The mean value and the standard deviation of each solution are provided in Table 2.

- ZTD estimation

The effect of the troposphere on GNSS and VLBI signals contributes as an additional delay in the measurement of the signal travelling. The magnitude of this delay depends on the temperature, pressure, and humidity as well as the antenna location. Taking advantage of GNSS and VLBI co-located antennas in Wettzell, VLBI-based ZTD estimated with VieVS has been compared to GNSS-based ZTD provided by IGS products. The mean value of the differences for the period analyzed is 4 mm, with a standard deviation of 7 mm.

5 Conclusions and Future Plans

The results presented in this poster lead to the following conclusions:

- Concerning EOP estimation, the accuracy of the IGE VieVS solution is within the same order of magnitude as other VLBI Analysis Centers. The IGE Where solution seems to be one order of magnitude better than other Analysis Centers regarding polar motion components. Additional tests are foreseen to confirm these outcomes.
- The accuracy in the estimation of other products derived from VLBI processing, such as station coordinates and troposphere delay, shows good agreement with other VLBI solutions and techniques (GNSS).

In light of these results, the IGE team is driven to gain more experience in VLBI processing and to continue reprocessing geodetic VLBI sessions. The ultimate aim is to contribute as much as possible to IVS activities.

6 Figures and Tables

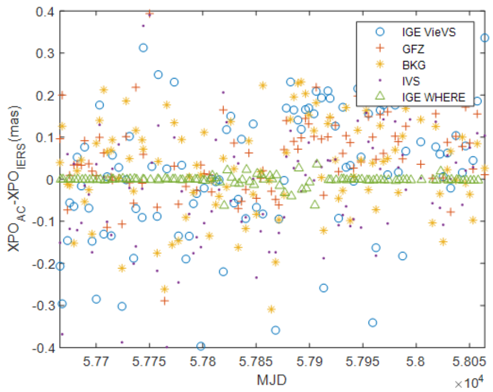

Fig. 1 X-pole differences with respect to IERS Bulletin B EOP (Oct ‘16-Oct ‘17).

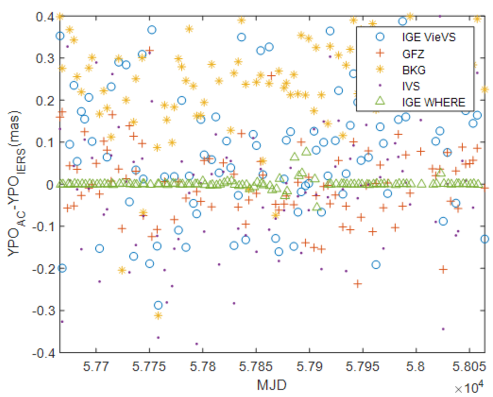

Fig. 2 Y-pole differences with respect to IERS Bulletin B EOP (Oct ‘16-Oct ‘17).

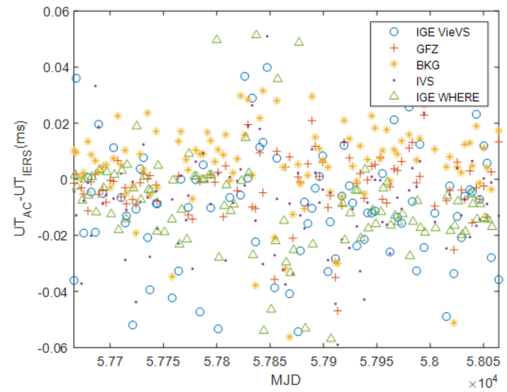

Fig. 3 UT1-UTC differences with respect to IERS Bulletin B EOP (Oct ‘16-Oct ‘17).

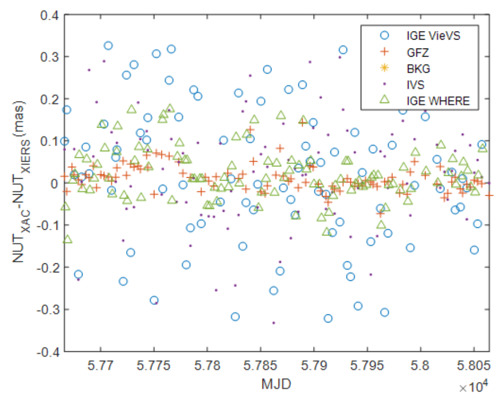

Fig. 4 dX differences with respect to IERS Bulletin B EOP (Oct ‘16-Oct ‘17).

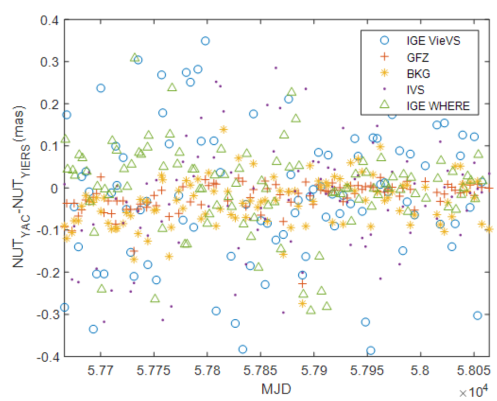

Fig. 5 dY differences with respect to IERS Bulletin B EOP (Oct ‘16-Oct ‘17).

Table 1 EOP differences statistics.

EOP	Solution	Samples	Mean	STD
X-Pole (mas)	IGE VieVS	108	0.156	0.206
	IGE Where	103	0.006	0.012
	BKG	109	0.112	0.169
	GFZ	109	0.178	0.558
	IVS	96	0.089	0.108
Y-Pole (mas)	IGE VieVS	108	0.198	0.258
	IGE Where	103	0.005	0.013
	BKG	109	0.314	0.172
	GFZ	109	0.207	0.579
	IVS	96	0.069	0.090
UT1-UTC (ms)	IGE VieVS	108	0.590	5.490
	IGE Where	103	0.021	0.032
	BKG	109	0.557	5.456
	GFZ	109	0.593	5.468
	IVS	96	0.017	0.082
dX (mas)	IGE VieVS	108	0.590	5.490
	IGE Where	103	0.021	0.032
	BKG	109	0.557	5.456
	GFZ	109	0.593	5.468
	IVS	96	0.017	0.082
dY (mas)	IGE VieVS	108	0.291	0.656
	IGE Where	103	0.048	0.062
	BKG	109	6.403	0.675
	GFZ	109	0.787	5.811
	IVS	96	0.024	0.033

Table 2 Difference in the norm of Wettzell coordinates.

Solution	Mean (m)	STD (m)
IGE VieVS	0.014	0.007
BKG	0.018	0.007
GFZ	0.013	0.016

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